Toxic Math-masculinity: Changing Harmful Lay Theories of Mathematics to Improve Student Achievement

by

Zac Kamm

A capstone project submitted in partial fulfillment of the requirements for the degree of Master of Arts in Teaching.

Hamline University

Saint Paul, Minnesota

May 2021

Primary Advisor: Julia Reimer

Project Summary

After training to become a mathematics teacher, I slowly began to perceive certain stereotypes that I choose to call Toxic Math-sculinity. Toxic Math-sculinity describes the cultural perceptions around mathematics that determine how people, especially students, view mathematics. The term Toxic Math-sculinity is inspired by the concept of Toxic Masculinity where men and women are socialized to perceive their gender performance as something essential and normative. This can be connected to many psychological effects (among other effects) that are harmful for both groups. Toxic Math-sculinity is the harmful belief that there are Math-People and non-Math-People and that to be a "Math Person" is to be smart and capable of effortlessly solving problems, while being a "Non-Math-Person" is to be less intelligent and to be incapable of learning mathematics. The resulting belief structure harms both high-achieving and low-achieving students. My anecdotal experiences led me toward considerations of how this Toxic Math-sculinity affects students in the math classroom and the question: *how can lessons focused on students' mathematical disposition change students' lay theories of mathematics and guide them toward pursuing learning goals?*

This project is intended to provide ten lessons that can be delivered in sequence at the beginning of the year to sixth and seventh grade math students. The theory of change, supported by research on lay theories of intelligence and goal orientation, is that students have a connected series of beliefs that influence their behavior and engagement in the math classroom. The most general is their lay theory of mathematics, the implicit understanding that many students have that mathematics is difficult and largely focused on quick, accurate calculation. This lay theory influences, and is influenced, by their lay theory of mathematical ability: whether they believe mathematical ability is a fixed

characteristic of a person (entity theory of intelligence) or whether it can grow and change (incremental theory of intelligence). A student's lay theory of mathematical ability has a strong influence on their goal orientation which is perhaps the most direct antecedent of their behavior in the classroom, both positive and negative.

The general structure of each lesson follows a Launch, Explore, Summarize format. The launch is meant to give context to the students for the day's lesson as well as activating their prior knowledge. It often takes the form of a class discussion. The explore portion of the lessons are meant to be student-centered activities that allow students to explore the essential question. The summarize portion of the lessons are intended to help students consolidate and express their understanding of the day's activities. The teacher's role in each lesson is mostly as a facilitator of discussion. Direct instruction is limited to the launch of some lessons, while the explore and summarize portions are meant as time for students to engage with the essential questions and express their "answer" in their own words.

The lessons are meant to be descriptive rather than prescriptive. The lessons assume that classroom discussion is a practice that students and teachers are comfortable and experienced with. The lessons also assume students are seated together in groups of about four, or could be regularly moved into such groups. Some of the lessons, especially those on grades, reflect my own practice and philosophy. A teacher wishing to follow those lessons is encouraged to modify them to fit their grading philosophy. Some lessons will require a teacher to create materials for use in the lessons. These are meant to be reflective of the environment or cultural background of an individual school. As such, I

have either provided a template with one example or noted that it must be created. A description of all materials not explicitly provided is included in the lesson plans.

It is hoped the lessons will provide a flexible framework for teachers to utilize as a whole class intervention. Much like the community building done in many secondary classrooms at the beginning of the year, the project is meant to set the tone for the remainder of the year. Each class will respond to different aspects of the lessons but the things that students connect with can continue to be referred to throughout the year. In some ways the project is focused on changing math teachers' lay theory of mathematical teaching from focusing on the content to focusing on the child's experience of the content.

Lesson Plan Structure

Students will be able to... The learning target for students in the given lesson.	**Essential Questions** The central questions that students will be attempting to answer during the Summarize portion of the lesson plan.
Materials Some materials are provided as a template and include a link to a Google Drive Folder with lesson templates and examples. Some materials will need to be created by the teacher. Descriptions of the materials that need to be created are found in the lesson plans.	
Launch The launch is meant to give context to the students for the day's lesson as well as activating their prior knowledge.	
Explore The explore portion of the lessons are meant to be student-centered activities that allow students to explore the essential question.	
Summarize The summarize portion of the lessons are intended to help students consolidate and express their understanding of the day's activities.	

Lesson 1

Students will be able to... *identify mathematical aspects of tasks outside of procedural calculation.*	**Essential Questions** "What is Math?" "What makes something a mathematics activity?"
Materials Computers/Tablets (One per student)	
Launch Ask students to think of an answer to the question "What is Math?" using examples or definitions. Students are expected to generate answers about numbers and calculation. To help	

them generalize their definition of math, you can ask questions to the whole class such as "Raise your hand if you think Math is just about numbers? Can anyone give me an example of a math problem without numbers." Students often identify word problems and variables as two topics that do not include numbers. This can yield a fruitful discussion about variables representing a number as well as how we use mathematics as an efficient way to model and understand things like word problems.

The conversation will necessarily be dynamic but you should lead students towards thinking about Mathematics as the study of patterns. Many students may be familiar with a definition similar to this so you can extend it to include "Mathematics is the study of patterns that help us become more efficient in thinking about the world and solving problems." A definition close to this aligns with the pedagogy of lower middle school classes where students are given models to help understand and motivate more abstract operations such as fraction multiplication and division.

Explore

Introduce the puzzle game 2048. One version may be found at https://play2048.co/ .

The controls of 2048 are simple. The arrow keys move all tiles on the screen in that direction. If two tiles with the same number are pushed together in this manner they form a new tile with the same value of the old tiles. Each time an arrow key is pressed, another "2" tile is added to a random location on the board. The game is over when there are no more open spaces on the board to place a new tile.

Most versions of the game available online will keep a running score (related to the sum of the tiles on the current board) as well as a high score. You can also encourage students to focus on getting a single tile with the largest value. (Ostensibly the goal of the game is to generate a tile with a value of 2048, but that is extremely unlikely to occur.)

One motivating strategy for students who are having trouble getting started or engaged is to set a target score when you demonstrate the mechanics of the game. In the past, a score around 1500 was approachable for all students. As students begin to play, circulate to check in with students expressing frustration or confusion. The game provides instant feedback which allows you to ask students to predict "What will happen if we press right?".

Summarize

After the students have explored the game for enough time to become familiar with the mechanics and gain some fluency, ask them to share strategies that they have discovered and as well as patterns they noticed. Good topics of discussion include: "What are some numbers that you will never see on a tile? How do you know?" as well as "Could you play this game with no numbers?". The latter question refers back to the definition of Mathematics from the launch. The pattern in the game is combining equivalent tiles which does not necessarily include numbers. There are variants of 2048 (which some students may be familiar with) that simply use pictures or colors on the tiles. The website https://all2048.com/ has many variants that

involve pictures (although the numbers are also included for convenience). Close by having students reflect (written or verbal) on what they felt when playing 2048. Empathize with students who expressed frustration and highlight those who persevered and reached an “aha” moment of understanding and enjoyment. Tell students “It can feel frustrating when you don’t recognize or understand a pattern and you might need some help from me or your classmates or your notes but I know you all will be able to understand the patterns we are studying this year.”

Lesson 2

Students will be able to… *identify a mathematician as anyone who engages in mathematical tasks.*	**Essential Questions** What does it mean to be a mathematician? Who can be a mathematician? What is a “math person”?
Materials Presentation (video or text) including quotes from staff members answering the question “Do you consider yourself a math person?” Guess the Mathematician Presentation	
Launch Ask students to reflect on the game 2048 and how they felt about the game as they played it. Introduce the video from Numberphile called “Professors Play 2048” (https://www.youtube.com/watch?v=00Qu1kgsGpM). Watching the whole video is not necessary, but the first three minutes are generally long enough for students to get an idea of their reactions. Ask students if they’ve ever felt like some of the professors, or if they’ve seen other students reacting to math the same way that the professors react to the game. Emphasize that even though the professors did not enjoy the game or were frustrated, they still talked about the mathematics and understood the patterns. “Even if math is not your favorite subject, you can still be a mathematician.”	
Explore Show a video or text quotes gathered from non-mathematics staff that asks the question “Are you a math person?” Ask students to share what they noticed or wondered from the video/quotes. Adults have a tendency to answer the question by reflecting on the math	

classroom or a specific teacher rather than mathematics itself. After discussion, remind students of the class's definition of mathematics from the previous lesson and then ask them to come up with a definition of a mathematician. Emphasize that we're talking about mathematicians, not being a math person. This allows students to separate their feelings about math from their understanding of math as an activity. The goal is to guide the class to define a mathematician as someone who does mathematical tasks such as recognizing and describing patterns rather than define it based on skill.
Summarize Students will play a game of "Guess the Mathematician". Students will see sets of pictures that include current and historical mathematicians and are asked to pick out the mathematician(s) from the set. If students express a biased view of who the mathematician is (e.g. picking the only male) help them interrogate that prejudice. The mathematicians included are meant to mirror the diversity of the class and have students confront the internal assumptions that they might have about who can be a mathematician. There are many websites and other resources dedicated to recognizing current mathematicians from different backgrounds including Latinx and African-American mathematicians. The mathematicians' accomplishments don't necessarily have to be relevant or intelligible to the class but it is meant to underscore the fact that mathematical achievement is possible for all students.

Lesson 3

Students will be able to... *identify times when they are functioning as a mathematician.*	**Essential Questions** When are you engaged in mathematical tasks outside of the math classroom?
Materials Computers (One per student)	
Launch Ask students to share out anything they did over the week or weekend outside of the math classroom where they were acting as a mathematician. Video games often include patterns and can be a fruitful and engaging topic of discussion if you are familiar with the games that students enjoy. Minecraft, in particular, remains popular and involves calculation as well as estimation. Introduce students to Exploding Dots from the Global Math Project	

(https://www.explodingdots.org/). The videos embedded throughout the website offer an engaging introduction and allow students to proceed at their own pace but you may wish to present exploding dots to your students yourself and do a gradual release of responsibility by working through 3 or 4 problems together before moving on to computers. Exploding dots is a way to think about different bases in a number system. Each box in the "machine" is a place value and when the number of dots would overflow or be carried over they explode instead. The machine model helps motivate addition, subtraction, and division as well as general number system fluency. You may register as a teacher and provide students with a group link that will track progress across all of your classes.
Explore Allow students to explore the first few "islands" of Exploding Dots while circulating to help explain some concepts.
Summarize As an exit ticket, ask students to explain what is mathematical about the Exploding Dots that they have been exploring. What patterns did they notice? How did it help them become more efficient? Close by emphasizing that the power of mathematics lies in creating models to help us understand things better.

Lesson 4

Students will be able to... *identify the characteristics of a growth mindset.*	**Essential Questions** "How do you get better at something?"
Materials Computers (One per student) Growth/Fixed Mindset Card Sort	
Launch Show Jo Boaler's introduction to Growth Mindset. (The first 30 seconds are in introduction to Jo Boaler's Week of Inspirational Math and can be skipped.) Ask students to reflect on something that they have gotten better at with more practice and then share out the experience. Because juggling is mentioned in the video, some students may want to demonstrate juggling. In my experience, this is a good time to demonstrate (or feign) your own poor juggling skills and ask the question "Is <student> smarter than I am? No, they've just had more practice and they've learned how to juggle." This can be a concrete example for students to think about. Allow students to share other examples so that it is clear that skill can be improved in all areas.	

Depending on the student population there may be sequential bilingual speakers who remember or are still in the process of learning a second language which can be another good example of a skill that takes a long time to learn. Tell students that some people believe that their abilities are fixed and you can't do anything to change that and there are some people who believe they can grow their abilities through practice. Some people have a fixed mindset about some activities ("I'm not a good cook") while having a growth mindset about others ("I need to practice more so I can try out for the soccer team"). Provide students with a definition of Growth or Fixed mindset. Many school sites have a common definition used in their social-emotional curriculum that can be utilized. It can be useful to include short example phrases such as "Growth Mindset-- I can do it if I keep practicing" and "Fixed Mindset-- I'm not a math person".
Explore Put students into groups and ask them to complete a card sort of quotes expressing a growth or fixed mindset. Each fixed mindset quote should have a matching growth mindset version. To make the lesson more valuable, utilize actual or invented quotes from students that you have overheard in classes or the hallway. Students may be more easily able to identify "I'll never be any good at FIFA" as an expression of a fixed mindset rather than a quote which involves math. Their mathematical mindset may be more internalized and harder to interrogate for students. As a class, discuss if the fixed mindset versions are "true". The goal is to have students recognize that having a fixed mindset might prevent them from trying or practicing. As mentioned in the video, that stops the synapsis from firing and can even shrink parts of your brain. After the card sort, give students the opportunity to explore more islands in Exploding Dots. Emphasize that they are working on growing their brains.
Summarize At the end of the lesson, ask students to reflect on how they have improved in using the Exploding Dots model over the course of the lessons and whether or not they have been utilizing a growth mindset when engaged in the activity. This works best as a whole class discussion where you can ask students for specific thoughts or self-talk that they used to persist in the task.

Lesson 5

Students will be able to... *identify mistakes in mathematical tasks.*	**Essential Questions** "Do mistakes mean that you don't get it?" "How do you react to mistakes?" "Is there good math before the mistake?"

Materials Catch my Mistake Worksheet *(template provided in the project files)*
Launch Start by asking what students remember about growth mindset from the previous lesson. Ask students “Does making a mistake mean you are not a mathematician?” Remind students of the class definition of a mathematician as someone who does mathematical tasks. Use the language from Jo Boaler’s video, especially the talk about synapses firing and growing your brain. Emphasize that there are some mistakes that happen because no synapses are firing (“I sometimes forget how old I am”) and there are some mistakes that happen when your brain is growing. “By learning to recognize and recover from your mistakes, you can make the synapsis fire twice and grow your brain even faster”. (This is not exactly how brains work, but is a great lens for students who may be focused more on correct or incorrect answers.)
Explore Break students into groups and allow them to start on the worksheets. Ideally each worksheet would feature recent, actual student work (or a legible version that makes the same error) from the class. An example worksheet is provided in the materials that focuses on Factoring, Lowest Common Denominator, and Greatest Common Denominator. Students are asked to identify mistakes and estimate what percentage of the problem was done correctly. Depending on students’ comfort with percentages they can also use phrases such as “almost all correct” or “mostly correct”. The goal of the activity is to have students understand that a mistake or an incorrect answer does not invalidate the work that went into the problem.
Summarize Share some final problems with errors in them with the whole class. This time, add the question “What would you tell this student to help them correct their mistake?” An intended outcome is that students will mirror language used in this lesson and that you use in class and be able to say something similar to “Great work here, but there’s one small thing you need to fix.” As a final question, show an example problem where a student has simply written “IDK” or “I don’t know how to do this”. Ask what the mistake was. Ask what percentage of the problem did they get correct. Compare the 0% correctness of the answer with even the most incorrect example from the worksheet. At the end of class, make sure to re-emphasize that mistakes where synapses are firing are good mistakes, they help your brain grow.

Lesson 6

Students will be able to... *use strategies for encouraging positive*	**Essential Questions** “What can we do when we feel frustrated?”

self-talk both inside and outside of math class with a focus on how to respond to mistakes.	"How do you keep going after you've made a mistake?"

Materials

Self-Talk Scenarios Sheet *(template provided in the project files)*

Launch

Start by discussing common experiences of experiencing frustration or failure. Examples could include "How does it feel when you trip *up* the stairs?" or similar universal experiences. Ask students how they react and note that students don't assume they can never climb stairs if they make a mistake once. Introduce the concept of self-talk or things you can tell yourself to stay motivated or recover from mistakes. Use examples of negative self-talk that might be heard in math class such as "I don't get it, I'm not good at math" but apply them to other situations such as saying "I don't get it, I'm not good at walking up stairs". The application of those phrases to ordinary situations will be humorous and help students understand how the thoughts themselves have power to motivate.

Explore

Give students some scenarios to discuss in groups. These group discussions will ask them to imagine the reactions of a third party which allows some emotional safety in the discussion and asks them to connect to things they might not have first hand experience with (such as not making it on to a sports team). The first scenario will be a model for the latter scenarios. Students will start by being given negative self talk and then asked to write a more positive response. As the scenarios progress, students will be asked to write the negative self-talk as well, asking them to imagine the negative thought processes that might be happening and then responding with a more positive version.

Summarize

Each group will share out their positive self-talk for each scenario. Have the class discuss the common elements in each of the responses. Students' exit tickets will consist of two to three personal scenarios that tie into the mistakes from the last lesson. Students are asked to reflect on how they would feel in a given situation and how they could use positive self-talk to keep themselves motivated.

Lesson 7

Students will be able to... *set learning goals for themselves.*	**Essential Questions** "How do you set goals for yourself?" "How do you check that you are making good progress with your goals?"

Materials

SMART Goals Presentation *(provided in the project files)*

SMART Goals Worksheet *(template provided in the project files)*

Launch

SMART goals are a way for students to conceptualize and plan smaller goals. SMART is an acronym where each letter stands for a different characteristic. These are phrased differently depending on the intended audience. For the purposes of this project I use the following words, along with examples and non-examples to help students understand.

Specific -- Break large goals down into smaller parts. Your life goal might be to become a doctor but a SMART goal would focus on doing well in the math and science classes you have now.

Measurable -- How will you know when you've achieved this goal? Getting better at skateboarding is a good goal, but an even better goal would be trying to learn a specific trick on the skateboard.

Achievable -- Do you have the power to make this goal happen? Focus on things that you have control over and goals that are realistic for you. If you set a goal to be seven feet tall by the end of the year, that's not really achievable.

Relevant -- Does this goal matter to you right now? Making a lot of money might be a goal you have when you are older, but right now there are more important things to focus on. Think about what is important to you now.

Timely -- How often will you check in on your progress? When do you want to complete the goal? Timely goals have deadlines or checkpoints to help you stay motivated and focus.

Explore

Have students work in groups on the worksheet (example provided in the materials) that asks them to break Big goals down into a starting SMART goal. Students will write a goal and then justify why it is specific, measurable, achievable, relevant, and timely. It may be beneficial to work through the first goal together so that you are sure that the class understands the purpose of each letter in SMART. Students often have trouble with explaining why a goal is relevant to them/the scenario.

Ask groups to share out the goals they wrote for each scenario and then explain why they thought the goals were SMART.

Summarize

Give students ten minutes to think of a SMART goal for the next month of math class and a SMART goal for the remainder of the school year in math class. Provide them the same justification template that was used in the Explore phase of the lesson so that they can explain why their goal is SMART.

Lesson 8

Students will be able to... *explain the purpose of grades.*	**Essential Questions** "What do grades mean?" "What is a fair grade?"
Materials Grades Worksheet *(template provided in the project files)*	
Launch Start a whole class discussion on the purpose of grades in a classroom. Be sure to ask if students would do an activity if it weren't graded. Guide students toward the multifaceted role of grades: motivation, structure, feedback. After students share their opinions, share (or re-share) your grading philosophy. Compare it to the all-or-nothing "traditional style" where grading is an either/or binary. Ask students to recall the mistakes worksheet from Lesson 5 and consider whether a student who is "mostly correct" should get zero points because they weren't "totally" correct.	
Explore Put students into groups and tell them they are taking on the role of a teacher today. They will be given student work and asked to make corrections and assign a grade. Like a teacher, they will also have to justify why their grade is a fair grade. The problems can be the same problems from Lesson 5 or problems from more recent work. Give the students a context for each problem that matches your classroom's grading system. For example, identify if the problem was on classwork or on a test or quiz, assuming that classwork grades are based on apparent effort and tests utilize standards based grading.	
Summarize As an exit ticket, have students imagine they are a Math teacher and write a few sentences on	

what their grading policy would be. After students have taken time to write, have students share out their philosophies.

Lesson 9

Students will be able to... identify positive and negative experiences that they have had in the math classroom and how it has impacted how they perceive math.	**Essential Questions** "How do you feel about math?" "How has your experience shaped how you feel about math?"
Materials Math Experiences Worksheet *(copy provided in the project files)*	
Launch Ask students to think-pair-share two positive math experiences and two negative math experiences that they've had. After partnering, ask students to share with the class a few of their experiences, both positive and negative. Ask students to notice what makes an experience positive and what makes an experience negative. Be sure to help students understand that some of these experiences are focused on the math classroom (e.g. a teacher that they enjoy, classmates who annoy them) while some are focused on the subject (e.g. a unit that they enjoyed or a part of math they struggle with). Both are valid experiences, but sometimes students or adults conflate their experiences in the classroom with their experience of mathematics, to both positive and negative effect.	
Explore Give students time to work on the worksheet that allows them to reflect on their math experiences. The worksheet also serves as a survey that asks students for feedback on your classroom. The reverse side of the worksheet asks students to draw themselves as a mathematician. Completed pictures can be used as classroom decoration, complimenting the definition of mathematics and mathematicians that may also be hung around the room.	
Summarize There will likely be enough time after students are finished with reflecting on their experiences to play a math (or non-math game). Ask the students which activity they would like to do as a class with the remainder of the time. Emphasize that the classroom is focused on choice. They might not always get to choose what they do (except in situations like the current one) but they	

know they choose how to respond to things in class.

Lesson 10

Students will be able to... start conversations with parents/guardians/siblings about mathematics.	**Essential Questions** "Does how your parents feel about mathematics affect how you feel about mathematics?"
Materials Mathematical Experiences Questionnaire *(copy provided in the project files)*	
Launch This activity is not expected to take a full class period. It can be supplemented with engaging tasks such as number talks or other activities introduced in class that allow for conversations around mathematics and patterns. Tell students that they are going to be given a chance to share the learning you've been doing in class with their parents/guardians/siblings. Sharing out the learning is meant to allow them the opportunity to start discussions at home about math. In class they will be filling out their side of the questionnaire and then interviewing someone to complete the other side.	
Explore Have students complete their side of the questionnaire which will largely mirror the class' definitions of mathematics and mathematicians as well as growth mindset and the purpose of grades. This serves as a good consolidation of their learning in the unit.	
Summarize Students should be tasked with interviewing a parent, guardian, or sibling using the other side of the questionnaire. The questionnaire is set up so that they can fold it in half vertically and have a parent fill it out without seeing their answers, but the preferred method would be to interview the parent. Students can share out what they learned or noticed in these conversations during the next class period.	